MODIS DATA STUDY
TEAM PRESENTATION

August 10, 1990

AGENDA

1. Comparison and Recommendation of the DAAC to Process Level-2 Data Products (Riggs)
2. MODIS Level-1 Context and Data Flow Diagrams (Study Team)
3. Data Dictionary (McKay)
4. Attributes of One Possible Realization for a MODIS Level-1B Standard Scene (Ardanuy)
5. Geolocation Errors for MODIS at Nadir (McKay)
6. Receive Platform Ancillary Data (Schols)
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COMPARISON AND RECOMMENDATION OF THE DAAC TO PROCESS LEVEL-2 LAND DATA PRODUCTS

MODIS SCIENCE DATA STUDY TEAM
6 August 1990

In this document, we address two questions:

- What are the advantages and disadvantages in processing MODIS Level-2 science data products for the land discipline at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland versus at USGS's EROS Data Center (EDC) in Sioux Falls, South Dakota?

- Based upon an examination of these tradeoffs; where should Level-2 land data product processing be done to most effectively accomplish the task?

For both GSFC and EDC, three major areas related to data processing capabilities were studied within the context of the EOS and EOSDIS goals of making available science data for the study of global change:

- Personnel

- Continuity of data flow

- Production facilities

Topics discussed within the major areas and how they would affect data processing are presented in a pro or con format for either facility (Table 1), and proceed from the following base assumptions:

- Level-1 data product generation will be performed at GSFC.
- Level-1B data will be archived at GSFC.
- Level-2 data products will be stored at GSFC if they are produced there, even if EDC is the long-term archive.
- Level-3 and -4 MODIS land-discipline science data product generation will be performed at EDC.

Based on our current knowledge of the two facilities' capabilities, we recommend that the GSFC DAAC process land Level-2 data products. Factors weighing heavily in favor of GSFC are:

- The large complement of scientists on MODIS science, technical, data, and calibration teams on site at GSFC, implying that they could be directly involved with processing and quality assurance of the science data products as they are generated

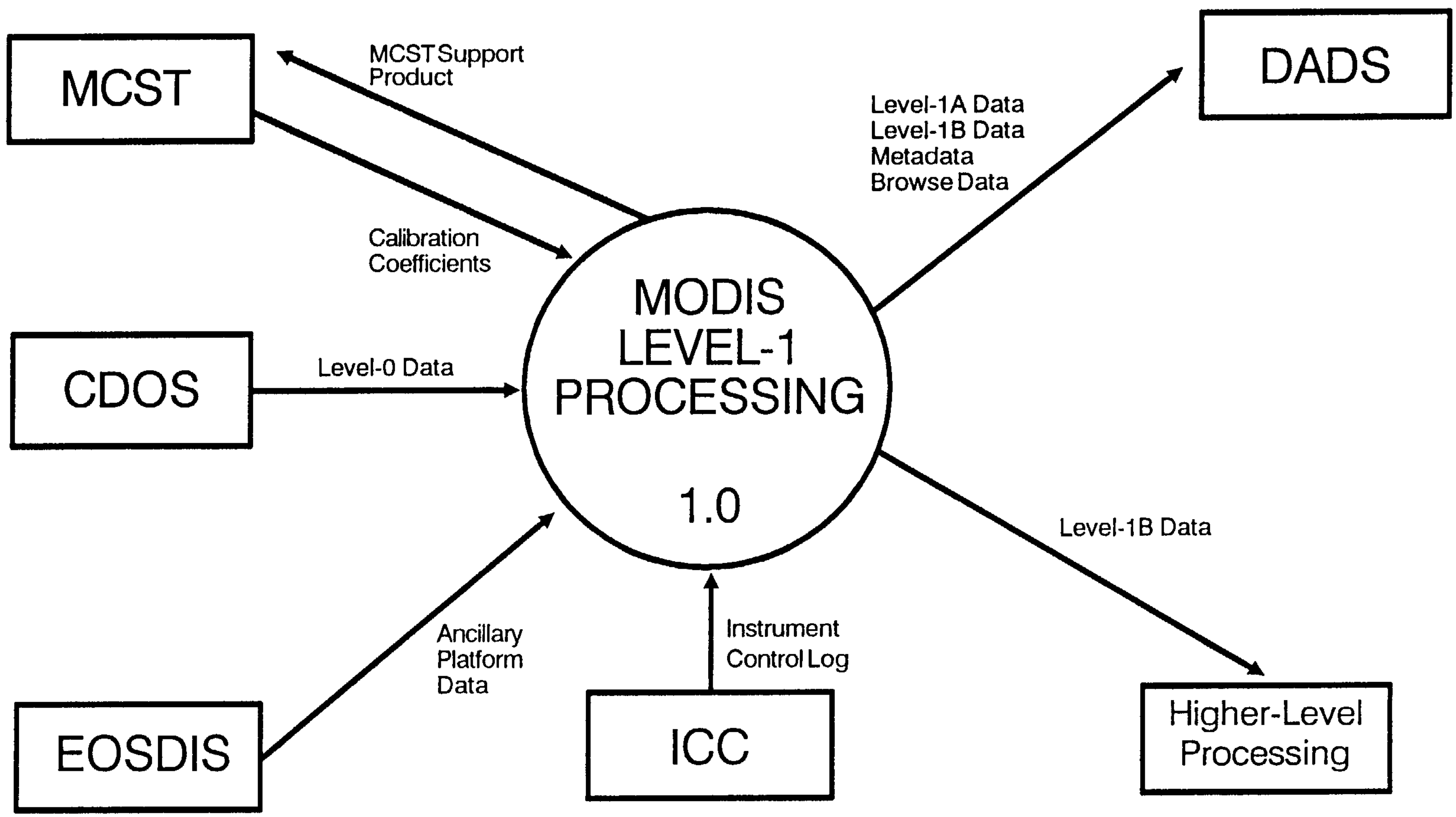
- The advantage of avoiding an interruption of data processing flow at a critical point (Level-1 to Level-2) to transmit Level-1B data to EDC, an action that may delay processing and output of science data products; also, at this point the maximum volume of data must be transmitted, a lesser data volume is encountered if only Level-2 data products are latter transmitted

- The anticipated iterative reprocessing of data with revised calibrations, alternative Level-2 algorithms for existing data products, or to exercise algorithms for the generation of new Level-2 data products, will demand that data be reprocessed beginning from Level-1B (processed and archived at GSFC); reprocessing requires that the entire volume of Level-1B data be retransmitted to EDC. This is in addition to the routine volume of data being transmitted, or alternatively redundant storage of Level-1B data at EDC (but the latter would be costly because of the volume of data that would be redundantly archived).

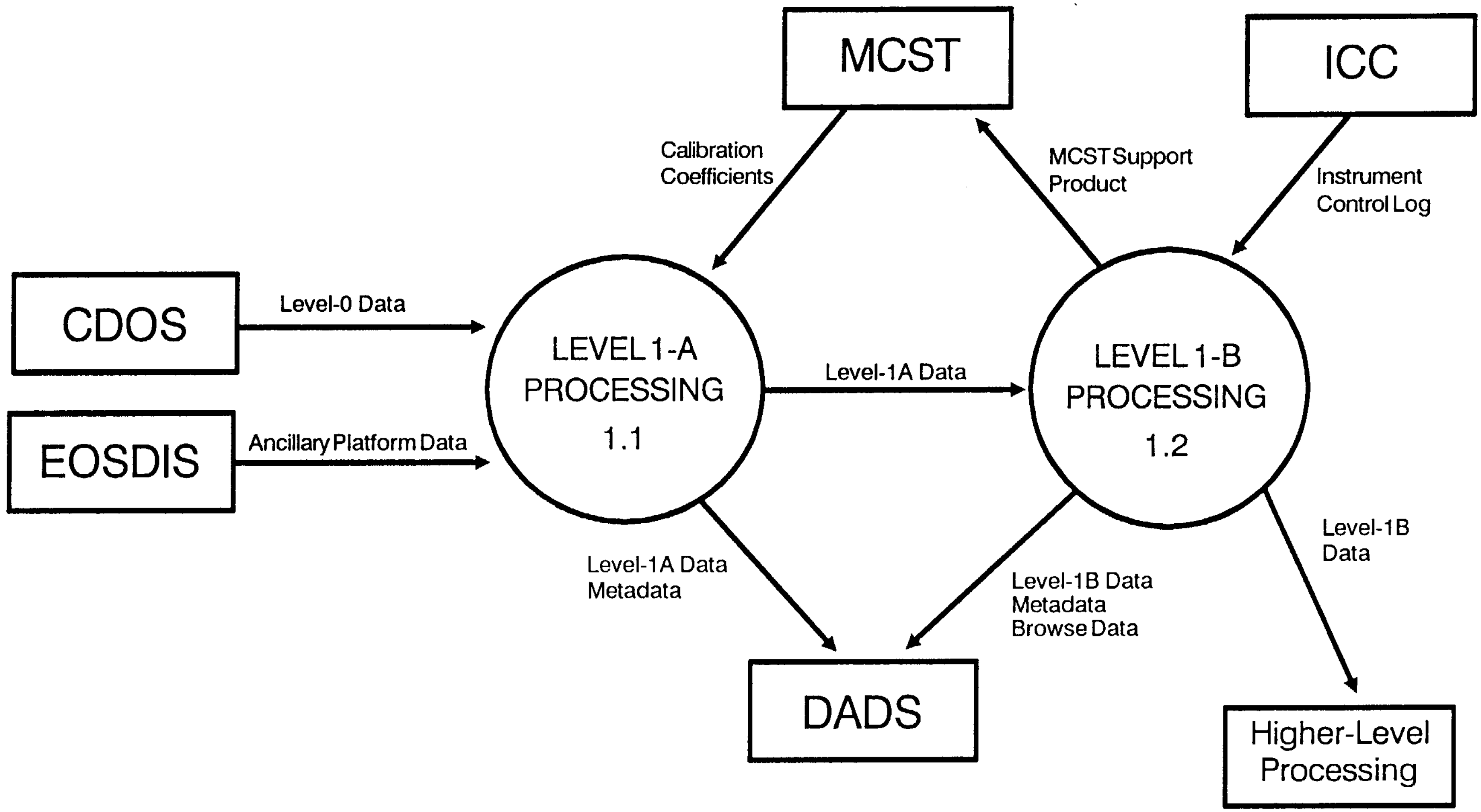
TABLE 1. COMPARISONS OF LEVEL-2 LAND DATA PRODUCT PROCESSING BETWEEN GSFC AND EDC.	PRO	CON
	SCIENTIFIC PERSONNEL	
GSFC	MODIS Science Team Leader; land, ocean, atmosphere group leaders; MCST, MTT, and MAST are all at GSFC; also several other MODIS Science Team members are at GSFC, and the SDST	
EDC		No MODIS Science Team members presently at EDC
	MANAGEMENT & PRODUCTION PERSONNEL	
GSFC	Has developed and currently using operational data processing systems for AVHRR (GIMMS), TOMS and other Nimbus-7 experiments, and Landsat; management and production expertise can be drawn from these systems	
EDC	Currently processing AVHRR data in near real time, and producing land data products operationally	
	DATA TRANSFER AND PROCESSING: Data Flow Continuity	
GSFC	Continuous data processing flow from Level-0 through Level-2	
EDC		Interrupt processing at end of Level-1 segment to transmit data to EDC for Level-2 processing
	DATA TRANSFER AND PROCESSING: Time Delays	
GSFC	Negligible delay in moving data from Level-1 processing segment to Level-2 processing segment	
EDC		Potentially significant delays in transmitting, verifying, and re-transmitting Level-1B data to EDC dependent on the communications link, could in turn delay Level-2 processing
	DATA TRANSFER AND PROCESSING: Data Volume	
GSFC	Data or data products must be transferred at some point to EDC; there is less Level-2 data product volume($\approx$43 Gbytes/day) to transmit than Level-1B data volume ($\approx$125 Gbytes/day)	
EDC		Larger volume of Level-1B data to ingest $\approx$125 Gbytes/day as compared to $\approx$43 Gbytes/day of Level-2 product data

DATA TRANSFER AND PROCESSING: Reprocessing as a result of revised sensor calibration		
GSFC	Reprocessing of Level-1B data from the archive and Level-2 product re-generation possible within the GSFC DAAC; no interruption for data transmission occurs	
EDC		Transmission of reprocessed Level-1B data required (assumed that EDC did not archive original Level-1B data); this implies a 2-5 factor increase in data volume to transmit, in addition to routine data transmission volume
DATA TRANSFER AND PROCESSING: Storage Issues		
GSFC		Processing and archiving Level-2 products at GSFC may result in a storage redundancy of products in archives at GSFC and EDC DAACs
EDC	Level-2 data products will be required as input to produce higher level products. This implies that Level-2 products may need to be stored at EDC from where they can be input into the higher level product data processing flow. Redundancy of storage may be reduced if EDC processes Level-2.	
DATA TRANSFER AND PROCESSING: Computers		
GSFC	CRAY YMP and IBM 3081 available for use; potential use of computers for both Level-1 and Level-2 processing	May have to purchase additional computer power to do Level-2 processing
EDC	Currently processing AVHRR data and producing vegetation data products for North America on MicroVAXs	These MicroVAXs will not be sufficient for volume of MODIS data processing expected; will require major procurement for purchase of computer system for Level-2 processing and order of magnitude shift in type of operations
DATA TRANSFER AND PROCESSING: Access to other EOS sensor data required for product production		
GSFC	Atmospheric EOS data to be processed at GSFC is required for atmospheric correction of the MODIS land leaving radiance product; implies fast convenient access to the atmospheric data	
EDC		Extensive communications links with other DAACs needed to import needed EOS data sets; may create logistical problems and delays in processing
DATA TRANSFER AND PROCESSING: Links with Ancillary Data Bases		
GSFC	Has links through NSSDC and NCDS	
EDC	Links being researched and developed	

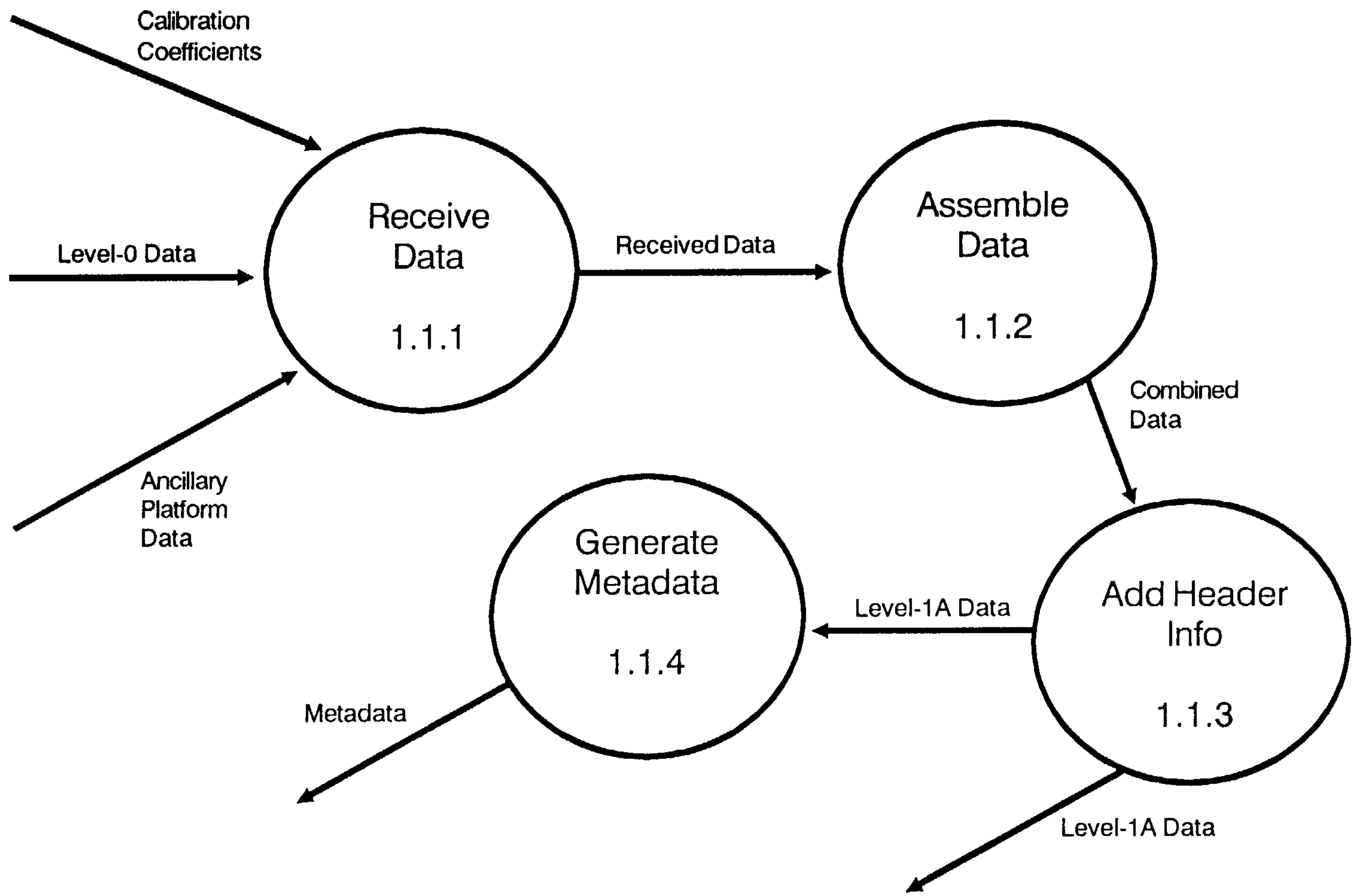
MODIS LEVEL-1 PROCESSING CONTEXT DIAGRAM



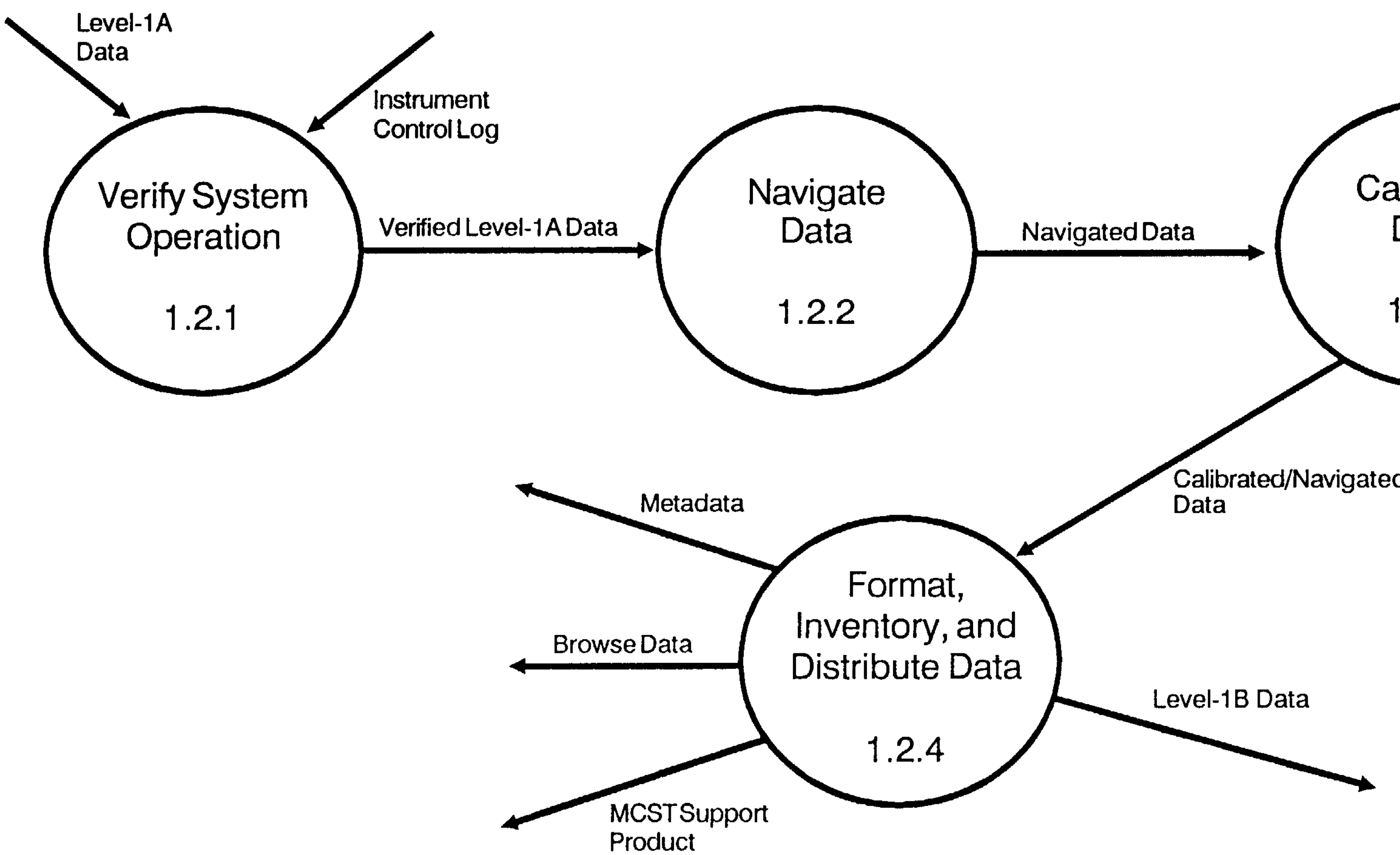
MODIS LEVEL-1 PROCESSING
DATA FLOW DIAGRAM (FUNCTION 1.0)



MODIS LEVEL-1A PROCESSING
DATA FLOW DIAGRAM (FUNCTION 1.1)



MODIS LEVEL-1B PROCESSING
DATA FLOW DIAGRAM (FUNCTION 1.2)



DATA DICTIONARY DEFINING LEVELS OF PROCESSING OF MODIS DATA	
DATA ITEM	**DATA DEFINITION**
Ancillary Platform Data	Platform location and attitude data used to navigate and monitor MODIS pixel locations, and other platform housekeeping data needed for Level-1 and higher processing[1].
Browse Data	Reduced spatial, spectral, and dynamic resolution data products routinely generated during MODIS processing to assist the ultimate data user in selecting MODIS data products suited to his needs.
Calibrated/Navigated Data	Integrated results of radiometric and navigation activities.
Calibration Coefficients	Numerical coefficients, parameters, or thresholds needed to apply the MODIS radiometric calibration using a Calibration Model.
Calibration Model	An equation or set of equations and an algorithmic procedure used to convert instrument-generated digital counts to corresponding spectral radiances.
Combined Data	Level-1A data suitably formatted for output but without header appended.
Instrument Control Log	A list of planned and actual events affecting the operational status of a MODIS instrument and associating a beginning time with each event.
Level-0	Instrument-Data at original resolution, time order restored, with duplicates removed.
Level-1A	Level-0 data which are reformatted, with Earth location, calibration data, and other ancillary data appended.
Level-1B	Level-1A data to which the radiometric calibration algorithms have been applied, to produce radiances or irradiances and to which the Earth-location and navigation algorithms have been applied.

[1]Will a chronology of platform events (maneuvers, service interruptions, etc.) be available? Where will the platform event chronology be developed? Should the platform chronology be integrated with the corresponding record for the MODIS instrument (Instrument Command and Response History)? Should a chronology of platform events be integrated into the mainstream of MODIS data (Level-1A)? Should status data from other payload instruments also be appended to MODIS Level-1A data? Are other platform data items needed in the MODIS Level-1A record?

DATA DICTIONARY DEFINING LEVELS OF PROCESSING OF MODIS DATA	
DATA ITEM	**DATA DEFINITION**
MCST Support Product	A data set containing selected MODIS digital counts and radiance data fields, and other relevant information. This product is routinely generated at the behest of the MODIS Characterization Support Team (MCST) and contains requested data items[2].
Metadata	Descriptive data developed during MODIS product generation to support user selection of MODIS data products using the facilities of the Information Management Center (IMC).
Navigated Data	Information specifying the computed Earth-location of MODIS pixels.
Received Data	A complete set of Level-0, Ancillary Platform, and Calibration Coefficient data that remains after data quality verification procedures are applied and inappropriate data are rejected. Received Level-0 data blocks have been entered in a Level-0 data receipt record.
Verified Level-1A Data	Level-1A data that remain after instrument operation checks are applied and data inappropriate for Level-1B processing is discarded[3].

[2]Is this product to be permanently retained? Should it be generated directly at the MCST without involving the Product Generation Facility? What operating modes will the MODIS instruments support? How many calibration modes are there? How will data from other instrument operating modes that do not include science data collection be stored? For example, will the instrument have an instrument test mode?

[3]Is it rejected or rerouted? If no Level-1A data is to be rejected for Level-1B processing because of instrument anomalies, the data flow diagram for Function 1.2 could be redrawn. The Verify System Operation bubble (1.2.1) would determine settings of data quality flags.

ATTRIBUTES OF ONE POSSIBLE REALIZATION FOR A MODIS LEVEL-1B (AND LEVEL-2) STANDARD SCENE

DESCRIPTION OF THE CONCEPT OF THE MODIS STANDARD SCENE:

- The concept is applicable for the purposes of computing metadata.
- The precise size of the scene should be left flexible for future refinement, though straw-man dimensions can be used).
- Each orbit is divided into 20 approximately equal-length segments (approximately five minutes), termed "scenes".
- The segments are defined based on the sub-satellite point (SSP) position.
- The first scene for each orbit begins with the first scan after the descending node.
- Each scene extends across approximately 18° of along-track angle (to within the closest scan boundary).

ADVANTAGES OF THE STANDARD SCENE CONCEPT:

- Convenient, approximately equal along-track/across-track dimensions.
- Scene definition is the same in terms of SSP for MODIS-N and MODIS-T.
- The scenes are standard in Earth latitude.
- The data are partitioned into manageable groups (20 per orbit).
- Data may be addressed by scene and orbit number (either absolute or within the 233-orbit repeat period).
- Data may be accessed by latitude, longitude, and date (using the added metadata).

DISADVANTAGES OF THE STANDARD SCENE CONCEPT:

- The size of the scene is arbitrary.
- Scenes containing the terminator may require special handling.
- When MODIS-T tilts, a relative displacement of MODIS-N and -T scenes along track will occur.

ATTRIBUTES OF ONE POSSIBLE REALIZATION FOR A MODIS LEVEL-1B (AND LEVEL-2) RECTIFIED SCENE												
Orbit Number	Scene Number	Start Orbit Angle	End Orbit Angle	Ascending/ Descending Node	Start Latitude	End Latitude	Along-Track Length	Duration (minutes)	Start Time (minutes)	End Time (minutes)	Number of Scans (MODIS-N)	Number of Scans (MODIS-T)
1	20	18	0	D	17.8	0.0	2000	4.9	93.9	98.9	291	62
2	1	0	-18	D	0.0	-17.8	2000	4.9	0	4.9	291	62
2	2	-18	-36	D	-17.8	-35.6	2000	4.9	4.9	9.9	291	62
2	3	-36	-54	D	-35.6	-53.2	2000	4.9	9.9	14.8	291	62
2	4	-54	-72	D	-53.2	-70.3	2000	4.9	14.8	19.8	291	62
2	5	-72	-90	D	-70.3	-81.8	2000	4.9	19.8	24.7	291	62
2	6	-90	-72	A	-81.8	-70.3	2000	4.9	24.7	29.7	291	62
2	7	-72	-54	A	-70.3	-53.2	2000	4.9	29.7	34.6	291	62
2	8	-54	-36	A	-53.2	-35.6	2000	4.9	34.6	39.5	291	62
2	9	-36	-18	A	-35.6	-17.8	2000	4.9	39.5	44.5	291	62
2	10	-18	0	A	-17.8	0.0	2000	4.9	44.5	49.4	291	62
2	11	0	18	A	0.0	17.8	2000	4.9	49.4	54.4	291	62
2	12	18	36	A	17.8	35.6	2000	4.9	54.4	59.3	291	62
2	13	36	54	A	35.6	53.2	2000	4.9	59.3	64.3	291	62
2	14	54	72	A	53.2	70.3	2000	4.9	64.3	69.2	291	62
2	15	72	90	A	70.3	81.8	2000	4.9	69.2	74.2	291	62
2	16	90	72	D	81.8	70.3	2000	4.9	74.2	79.1	291	62
2	17	72	54	D	70.3	53.2	2000	4.9	79.1	84.0	291	62
2	18	54	36	D	53.2	35.6	2000	4.9	84.0	89.0	291	62
2	19	36	18	D	35.6	17.8	2000	4.9	89.0	93.9	291	62
2	20	18	0	D	17.8	0.0	2000	4.9	93.9	98.9	291	62

Geolocation Errors for MODIS at Nadir

August 1, 1990

Random errors that could potentially affect the Earth location of MODIS pixels include platform-location uncertainties, platform navigation-base attitude uncertainties, platform distortion between the navigation base and the MODIS baseplates, and look angle uncertainties of the MODIS instruments with respect to the instrument baseplates. Table 1 lists 3σ error values **AT NADIR** for each error source. If present specifications[1] and design goals are met, the combined effect of navigation base attitude uncertainty and platform distortion will not exceed the 108 arcseconds/each axis value listed in the upper part of the Table. Because of uncertainty as to whether design goals can be met, a second scenario with navigation base uncertainty and platform distortion each equal to the currently specified combined effect is shown as an example in the lower portion of Table 1. Assuming a 705 km platform altitude, σ_{total} = 161 meters for each axis if current specifications are met, and by our assumptions, might equal about 200 meters if current specifications are not retained.

TABLE 1

Three Sigma Error Limits Associated with Geo-Location Parameters

BY CURRENT SPECIFICATION	
Platform location uncertainty	50 meters/each direction
Baseplate attitude uncertainty	108 arcseconds/each axis
Instrument look uncertainty	90 arcseconds/each axis
WITH ADDED PLATFORM DEFORMATION ALLOWANCE	
Platform location uncertainty	50 meters/each direction
Navigation base attitude	108 arcseconds/each axis
Platform distortion	108 arcseconds/each axis
Instrument look uncertainty	90 arcseconds/each axis

Assuming that errors about each axis are Gaussian distributed with zero mean and noting that, for the scenarios postulated, $\sigma_x = \sigma_y$, Earth-location errors are Rayleigh distributed in r, where r is the magnitude of the radius vector between true and computed pixel locations. If the distribution is integrated to obtain the probability of an computed location lying within a circle of radius R around the true location, we obtain the values listed in Table 2, where circle radius values have been specifically chosen to equal nadir pixel dimensions for the MODIS-N and MODIS-T instruments. Probabilities for these offsets may be particularly relevant for

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[1] General Instrument Interface Specification for the EOS Observatory, GE Astro Space [DRAFT], January 15, 1990

investigations that use pixel-by-pixel overlays of data from successive passes of the MODIS instruments. Table 3 lists circle radius values corresponding to the "three sigma" limit for a Gaussian distribution, i.e. the radius value for which the probability of being outside the circle just equals 0.0026. For observations not done at nadir, absolute errors increase although relative pixel proportions are retained, i.e. the probability of errors less than one-half a full-sized MODIS-N pixel dimension is still 0.97 at any satellite zenith angle if design goals are met and perhaps about 0.89 if goals are not met. The increase in absolute error could reach a factor of 4 to 6 over the nadir-looking location uncertainties at the extreme limits of a scan.

TABLE 2

Probabilities of Computed Location Being within a Circle of Radius R Centered on the True Location

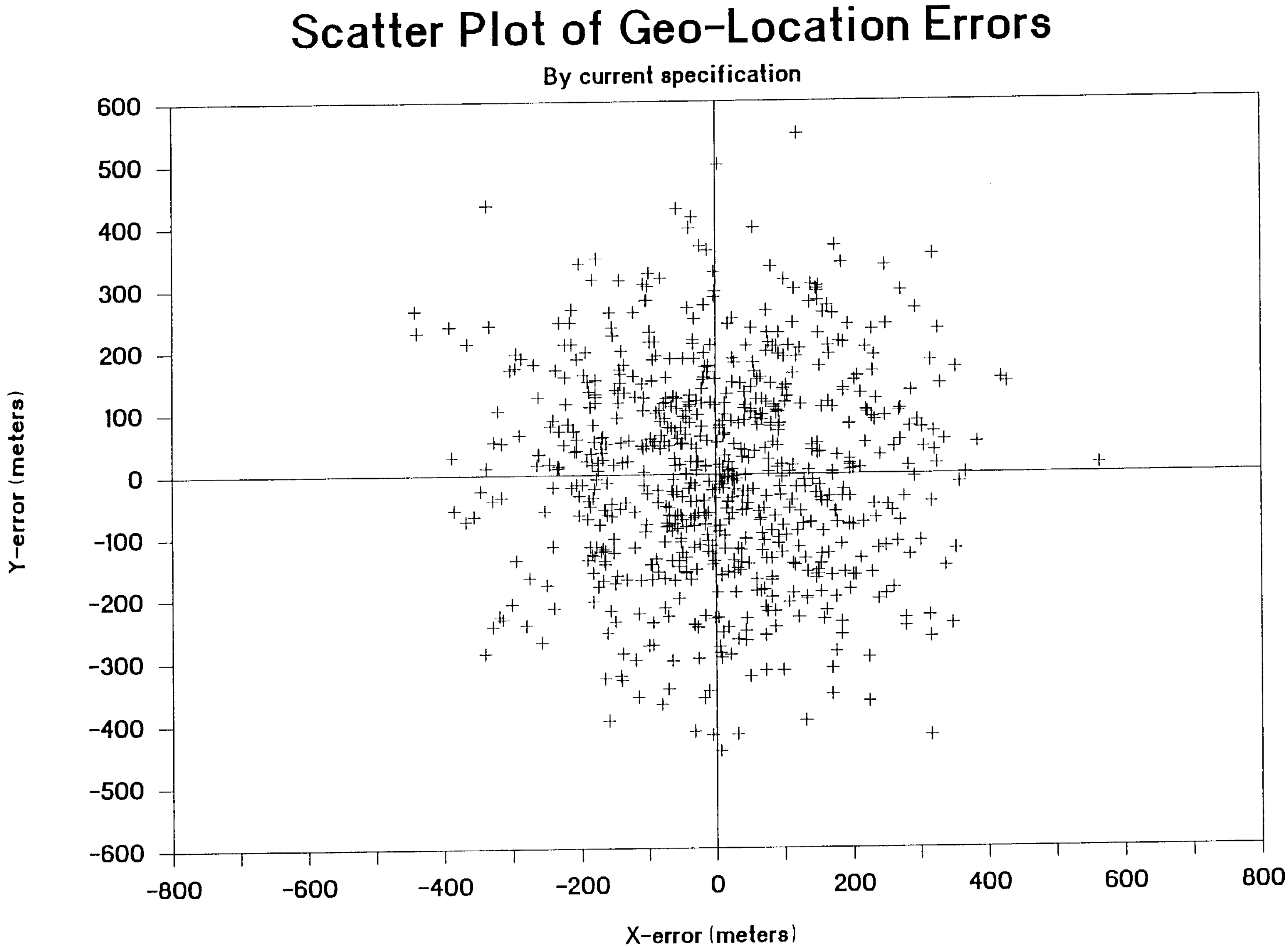
As currently specified (15 Jan 90)		With added platform distortion allowance	
Circle radius (meters)	Probability of being within circle	Circle radius (meters)	Probability of being within circle
214	0.59	214	0.43
428	0.97	428	0.89
856	0.9999993	856	0.99987
1100	~ 1.000000000	1100	0.9999996

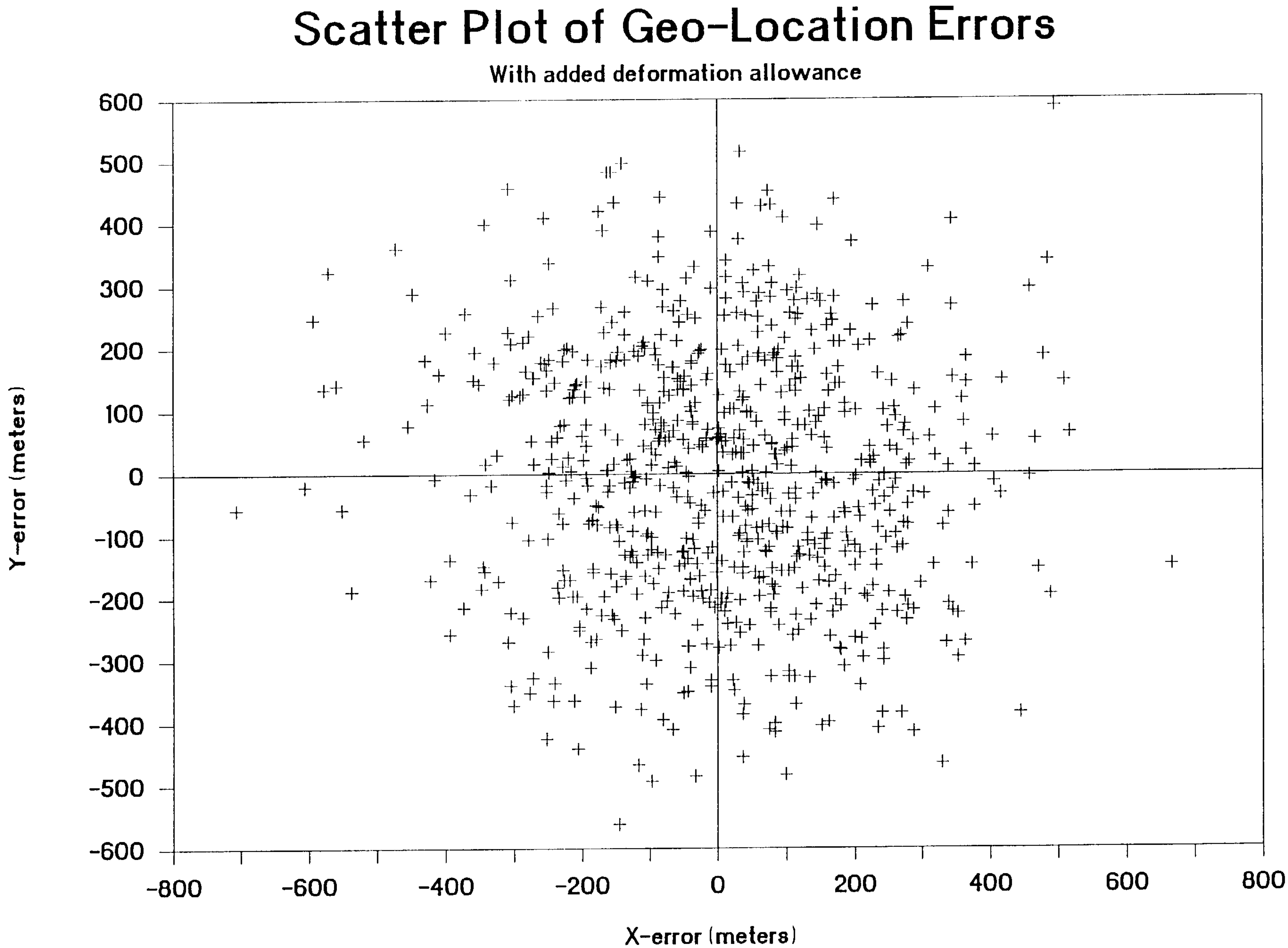
TABLE 3

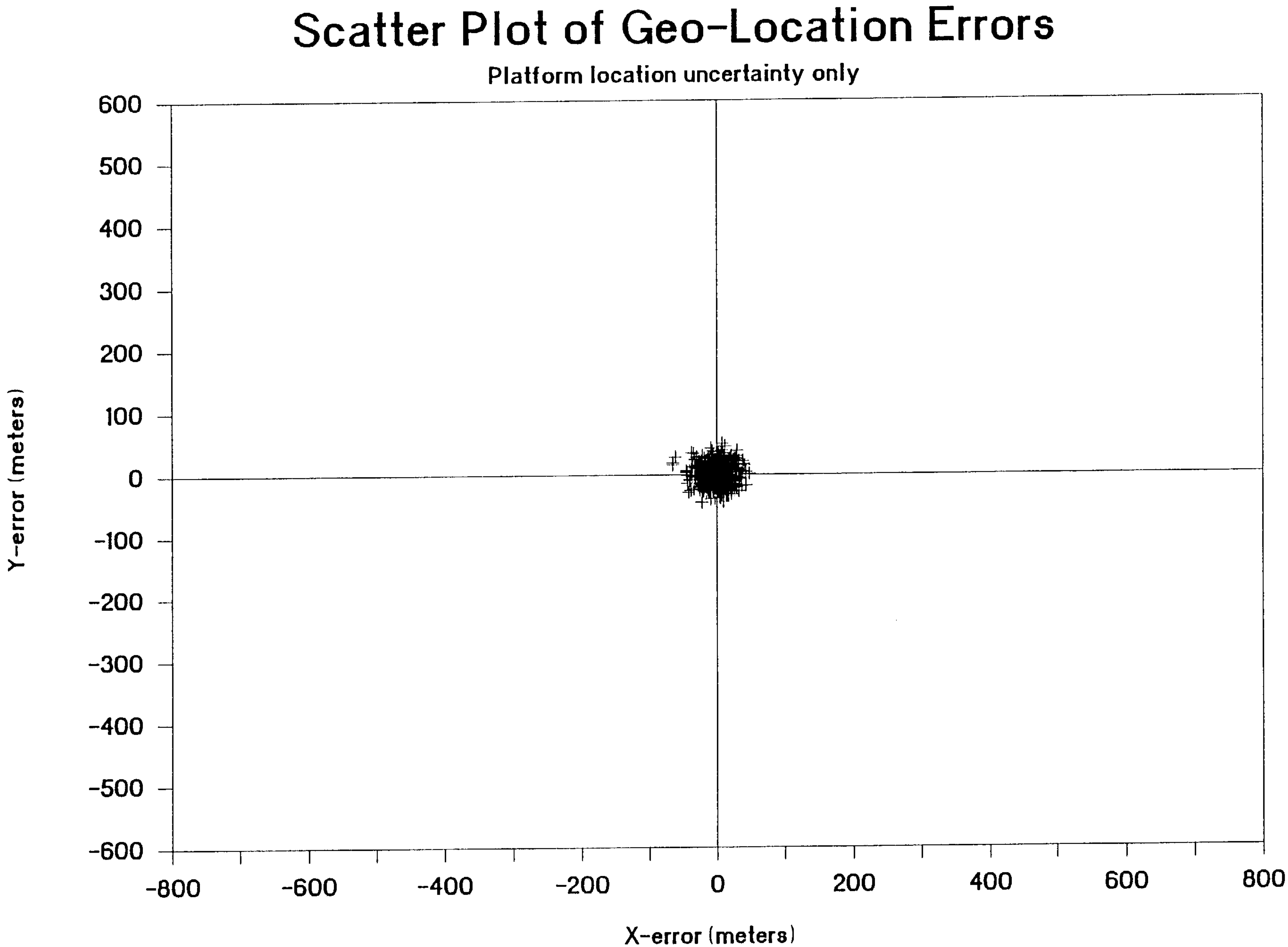
Radius Values Corresponding to Three Sigma Limits of a Gaussian Distribution

As currently specified (15 Jan 90)	With added platform distortion allowance
"3-σ" radius 554 meters	"3-σ" radius 697 meters

To illustrate the behavior of computed Earth locations with respect to the true locations, Gaussian distributed uncertainty about each axis was simulated to produce the scatter plots shown in Figures 1 through 3. Figure 1 shows simulated scatter if current specifications are retained; Figure 2 shows the corresponding scatter with an additional allowance for platform deformation and, for comparison, Figure 3 shows the Earth-location scatter that would result from platform position uncertainties alone if no attitude uncertainties existed. From this plot it is apparent that most of the Earth-location uncertainty results from attitude uncertainties.


Scatter Plot of Geo-Location Errors
By current specification
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
Y-error (meters)
-800
-600
-400
-200
0
200
400
600
800
X-error (meters)


Scatter Plot of Geo-Location Errors
With added deformation allowance
Y-error (meters)
X-error (meters)
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-800
-600
-400
-200
0
200
400
600
800


Scatter Plot of Geo-Location Errors
Platform location uncertainty only
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
Y-error (meters)
-800
-600
-400
-200
0
200
400
600
800
X-error (meters)

RECEIVE PLATFORM ANCILLARY DATA

The stream of ancillary data is separate from the Level-0 instrument science data stream. Standard format ancillary data will be distributed by the Platform Command and Data Handling (C&DH) Subsystem to the MODIS instruments over fixed time intervals. The ancillary data will be updated and distributed by the Platform Control Processor (PCP) to the Bus Data Units (BDU)s at intervals of no greater than once every 100 msec. Ancillary data will be supplied from BDUs to instruments over a serial interface, which is a bidirectional interface used to pass serial commands, memory loads, ancillary data, and serial housekeeping telemetry.

Ancillary data will consist of standard format messages that are 512 bits in length. The contents of the ancillary data messages are displayed in Table I. Each word in the ancillary data message will be sampled at a to-be-specified (TBS) fixed-time relationship with respect to the time tag.

Table I. Standard ancillary data contents (Platform-generated Ancillary Data List)[1]

Word Size		Data Type	Bit Length
3	32-bit Words	Platform Position	96 bits
3	32-bit Words	Platform Velocity	96 bits
3	12-bit Words	Attitude Angles	36 bits
3	12-bit Words	Attitude Rates	36 bits
3	8-bit Words	Magnetic Coil Currents	24 bits
1	8-bit Words	Solar Array Current	8 bits
3	8-bit Words	Solar Position	24 bits
3	8-bit Words	Lunar Position	24 bits
2	32-bit Word	Time Tag	64 bits
4	8-bit Words	GPS-to-UTC Time Conv.	32 bits
TBS		TBS	72 bits
Total Platform-generated Ancillary Data			512 bits

[1] General Instrument Interface Specification for the EOS Observatory (1/15/90).

APPEND PLATFORM ANCILLARY DATA

The platform ancillary data are going to be put in a header, which is appended to the MODIS instrument (science and housekeeping) data. The purpose of the platform ancillary data are to provide the instruments with routinely updated data consisting of time, guidance, navigation and control parameters (i.e. state vectors, platform attitude, and celestial body position), bus status, and other appropriate data). Some of this ancillary data will be needed for each anchor point, other information will only be attached to scans. It is therefore conceivable that more than one header will be used for appending the ancillary data. As an example, one of these headers could contain the vector for instrument status and also QC information.

How the header is going to be appended depends on how the header is organized compared to the science data. A scenario of two possible means of appending the header to the MODIS instrument data will be described in the following:

1. Locate the header inside a science data cube, which was described earlier (MODIS Data Study Team Presentation on Friday, July 13, 1990). In this cube, the science data (individual bands) are put in images, which are scans (or scenes, i.e. assembly of successive scans). The images are stacked on top of each other, along the vertical dimension, which represents wavelength. An image is a 2-D, pixel by pixel, representation of the science data, for a particular wavelength. The two dimensions in an image are cross-track and along-track. The header information is put on top of the upper level of the stack of science data images. The areas covered by the header and each image are the same. The header also contains the same number of locations (pixels) as a science data image. At the start of the Level-1 processing the header is filled with no information. While the Level-1 processing progresses, the header is filled with information about ancillary data, calibration, metadata, and other appropriate data. In this concept, the Earth locations do not have to be stored, but can be transferred by means of the header information.

2. For MODIS-N (MODIS-T) a scan line contains 1582 (1007) pixels, observed in 1.02 (4.75) seconds. Therefore, the time-spacing between pixel observations is 1/1582 (1/1007) seconds. The ancillary information will be provided at a 10 Hz rate, which means that this data will be more than an order of magnitude less densely distributed in time than the science data. This may be a good reason to place the header outside the science data cube as a separate piece of data. The ancillary data to be appended lies between (or just containing) the start and stop time of the science data in a cube. The connection between the ancillary data and the science data is to be made at the anchor points, after they have been selected.

METADATA

Metadata are information which will accompany MODIS science products and data to describe those items. Metadata, or data about data, perform the function of a card catalog and indices in a library. They are prepared at each data processing level, beginning at Level-1B (and possibly at Level-1A). The purpose of metadata is to permit the users to order the best data set or science product for their analysis. This information is not designed for use in standard processing, but it could be used for special products.

At Level-1, metadata relates science data to calibration, navigation, and instrument engineering data. Data recipients should be identified for future updates (when reprocessing occurs) and feedback to determine what use was made of the data.

Metadata functionally may be divided into four areas. (Since metadata is generated at each processing level, the actual products do not always nicely fit into this scenario.) These areas are:

- Directory level — This is a capsule description of the data sets.
- Amorphous level — This aids in searching and using data from certain instruments.
- Inventory level — This is composed of the "granules (i.e., the little pieces" in the data set). There is a description for each level.
- Browse level — This consists of images in an extremely condensed form[1].

Standard browse products permit the user to order data for a more extensive analysis. It performs the function of a catalog. The user will be conducting a search on a previously prepared product. The browse products is prepared at the time the a standard product is produced. It will be an extremely condensed image which is small enough to be transmitted electronically. It would routinely be sent to each science team member. Browse data is not used as input to algorithms.

Browse data will not be available for all products and all spectral bands; e.g., a subset of spectral bands in the visible may be used to produce a false color image showing the areal coverage for a scene over a given time period (an orbit, day, week, or month). Browse data will be available at on a dial-up basis.

It is possible to ask the system logical questions that it can not answer. One such simple question is the maximum radiance value from a certain pixel. In general, logical

[1]When extended browse data is being created, the user must have access to the Level-1B (or higher) data. As such, extended browse would be generated by the DADS after the product generation was complete and the products archived (and will not be considered in our Level-1 design).

questions which require the entire set of MODIS observations to be scanned to obtain an answer will not be serviced.

Some examples of possible MODIS metadata which have been identified[2] are listed below in a rough grouping by level:

- Sensor ID, platform ID, instrument operating mode, tilt angle, scan number, altitude, ephemeris information, solar/satellite zenith angle, orbital revolution number, calibration algorithm version number, instrument command and response history, data status.

- Product sequence number, algorithm version number, processing data, start/end time, number of observations, data quality, data gap, data processing location, processing level, latitude and longitude, parameter names, statistical summaries.

- Land/ocean tag, cloud information.

Metadata associated with data base management are:

- Metadata key words, cooperating non-EOS data centers, product identifiers and archive locators, product documentation, key personnel (for products and archives), product algorithm(s), algorithm documentation, version numbers for documentation and algorithms, statistical summaries.

- Instruments which produced the product, instrument configuration history, platform, instrument calibration data.

- Browse data associated with the product.

- Documentation associated with inventory (data quality assessments, research papers, etc.), research results, authors.

This information can be used to construct the DeMarco diagrams for each processing level. For the purposes of Level-1 processing system design, specific metedata items for Level-1A and -1B must be identified. Following this, the data flows and processing functions for metadata generation at Level-1A and -1B will be defined.

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[2] Phase C/D Requirements Specifications for the Earth Observing System Data and Information System Preliminary; 1 May 1990

LEVEL-1 BROWSE DATA

Browse data are compressed, sub-sampled representations of the actual data taken by the sensor. Their purpose is to allow a quick observation of the sensor data to facilitate ordering decisions. Thus the primary purpose is quality assurance. The user will use the browse data to see if data exist for the feature/region of interest, and what the cloud cover is. Browse data may also incidentally be useful for data quality verification and for scientific purposes - certainly such use is allowed - but the primary purpose of a browse product is to give a user an overview of available data so he can select data that meets his need.

Because of the tilt capability of MODIS-T, data will lose continuity along-track. For example, if MODIS-T is viewing the Earth with a 20° forward tilt, and suddenly changes to a -50° tilt, it will be viewing a region the satellite has already passed over. This will lead to discontinuity and make any scene representation difficult to understand. Stare mode will further complicate the situation. Therefore, browse data will be different for MODIS-N and T.

The requirements for browse data at Level-1B for MODIS are as follows.

MODIS-N and MODIS-T

1. Browse data will be in satellite coordinates (along-track, across-track)
2. Browse data will be made for Level-1B only, not Level-1A.
3. Browse data will conform to the "scene" concept and configuration used for metadata.
4. Browse data will be compressed data in 8-bit words, and sub-sampled spatially.
5. Only a small number of spectral bands will be used for browse data.
6. Information on the browse scene will state how many scans were lost, the start/stop time, and the date.
7. Latitudes and longitudes will be noted on the browse scene at the corners.

MODIS-N Only

1. A minimum number of spectral bands to be used for browse is three: 1 each from visible, near-infrared, and thermal infrared regions. A maximum might be 9 (see Table 1 for candidate bands).

MODIS-T Only

1. MODIS-T browse data will contain, in addition to the scene values, an along-track 8-bit tilt indicator (see Figure 1).
2. Information on the scene will state what modes were used and how many scans were in those modes.
3. The note will also state the tilts used and the number of tilt changes.

4. A minimum number of spectral bands might be one, the maximum might be 3 (see Table 1 for candidate bands).

Distribution

1. Media for distribution will be left up to the EosDIS contractor, but it must be generally useable by the scientific community and preferably also the general public. Some suggestions are on-line (electronic), videotape, microfilm, floppy disks, magnetic tape, or CD-ROM. The selection should be dictated by the prevailing media of choice in the user community near the time of launch.

Table 1. Candidate MODIS Browse "Data Products"

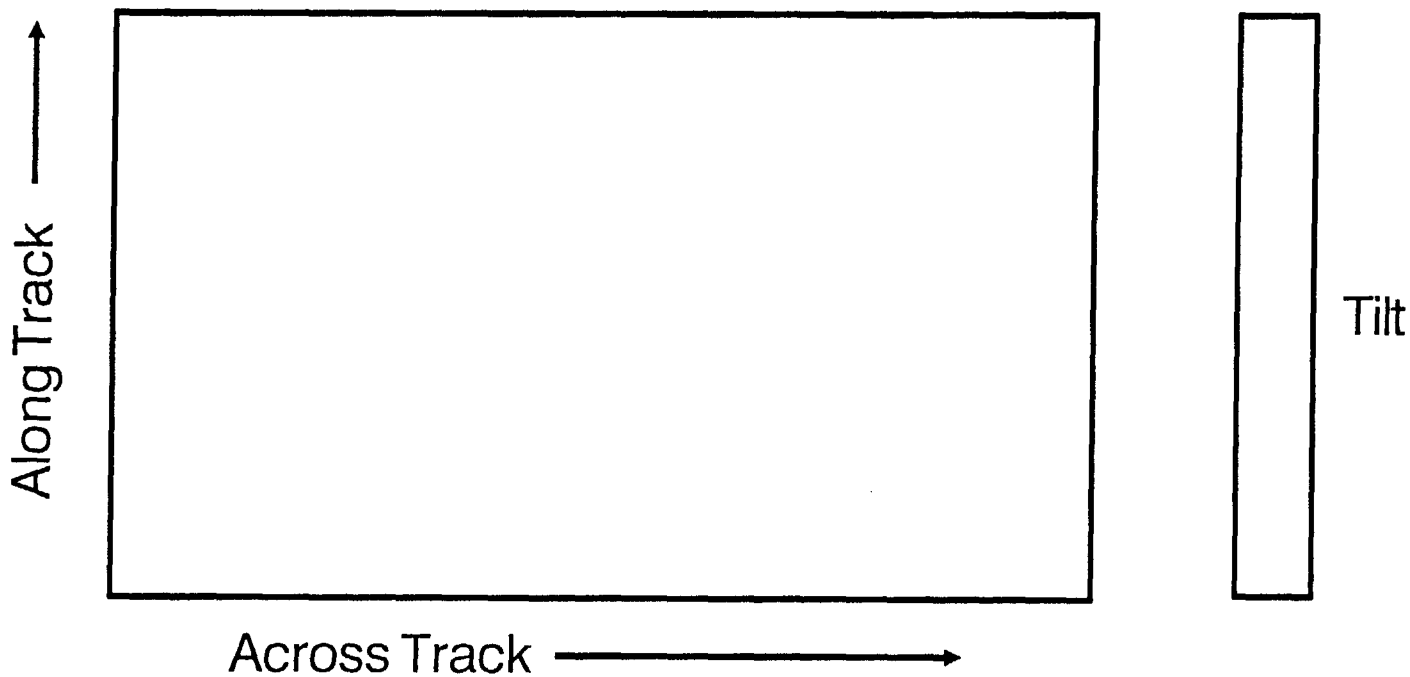
MODIS-N LEVEL-1 CALIBRATED RADIANCES AT THE TOP OF THE ATMOSPHERE

BAND	CENTER	DISCIPLINE	SPECTRAL REGION	PRIMARY PURPOSE
9	443 nm	ocean	blue	aerosols/clouds/glint
12	565 nm	ocean	yellow	aerosols/clouds/glint
15	745 nm	ocean	near-IR	aerosols/clouds/location ID
4	555 nm	terrestrial	green	green peak
1	659 nm	terrestrial	red	chlorophyll absorption
2	865 nm	terrestrial	near-IR	vegetation/land cover
6	1.64 μm	terrestrial	medium-IR	snow/ice discrimination
20/21	3.75 μm	terrestrial	thermal-IR	surface temp./volcanology
31	11.0 μm	multi-disc.	thermal-IR	surface/cloud temperature

MODIS-T LEVEL-1 CALIBRATED RADIANCES AT THE TOP OF THE ATMOSPHERE

BAND	CENTER	DISCIPLINE	SPECTRAL REGION	PRIMARY PURPOSE
3	440 nm	ocean	blue	aerosols/clouds/glint QC
11	560 nm	ocean	yellow	aerosols/clouds/glint QC
25	755 nm	ocean	near-IR	aerosols/clouds/location ID

MODIS-T LEVEL-1B BROWSE FORMAT



NOTES FOR EARTH LOCATION DISCUSSION

There are two frames in which it is reasonable to do the computation: the orbital frame, where the orbit plane and orbit normal define the coordinate system, and a geocentric frame, where the Earth's equator and pole define the frame. We should make sure that we have the necessary ancillary data to do it either way.

The required ancillary data for the Earth location process in either frame are:

- Platform position
- Platform velocity (for platform frame definition)
- Platform attitude
- Timing data to synchronize the ancillary data with the observations

The General Instrument Interface Specification for the Eos Observatory (15 Jan 90) indicates that these data will be available at a 10 Hz rate. In addition, we need the relative displacement and alignment of the instrument coordinate system with the platform coordinate system, which will be obtained from pre-launch measurements and perhaps updated during flight if bias studies can successfully determine improved alignment data. The required accuracy of these data has been discussed elsewhere and is still under review.

1. Geocentric Frame

The geocentric frame will likely be preferred if the position data are provided in a frame rotating with the earth.

Advantages:

Conceptual simplicity

Flexibility with regard to the shape of the Earth, since this is the natural frame for describing the Earth ellipsoid or geoid.

Disadvantages:

Calculation will be repeated for each anchor point.

2. Orbital Frame

The orbital frame may be preferred if the position data are provided in a frame fixed in space. This coordinate frame has been used on other spacecraft when the platform position was based on predicted orbital elements rather than onboard navigation data.

Advantages:

Some repeated calculations across a scan line can be saved.

Flexibility with regard to spacecraft motion, since this is the natural frame in which to describe its path.

Disadvantages:

More complicated algorithm for oblate earth.

Conceptually more difficult since orbit shape and orientation as well as Earth rotation must be accounted for.

3. Geoid Model

The question of sphere, ellipsoid, or geoid for the shape of the Earth must be investigated.

Sphere:

Errors on the order of 20 km can arise. Unacceptable.

Ellipsoid:

Errors on the order of 100 m will arise. These are in line with other uncertainties.

Errors could be removed by defining a digital terrain elevation data set to be elevations from ellipsoid instead of geoid. For ocean products, the error may be acceptable without further correction.

Geoid:

Most accurate model available.

Considerably more calculation will be required at each anchor point.

Trade studies between the ellipsoid and geoid are underway to determine the preliminary design choice.